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RAMAN AUGMENTATION FOR RAYLEIGH LIDAR (U)

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Raman detection has recently been added to the Air Force Geophysics Laboratory's ground-based lidar system (GLEAM) to augment that system's Rayleigh lidar measurements. In this paper we examine the possibilities of using the Raman measurements to self-normalize, and downwardly extend, our measurements of stratosphere and lower mesosphere molecular density.

By combining inelastic (Raman) and elastic (Rayleigh plus Mie) scatter measurements, one can isolate the Mie component of the scattering using the techniques of Cooney and correct the data to eliminate the effects of atmospheric attenuation.

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AFGL-TR-88-0232

Raman Augmentation for Rayleigh Lidar

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- Air Force Geophysics Lab.

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Raman Augmentation for Rayleigh Lidar

Extend lidar atmospheric density measurements downward to a convenient range for normalization.

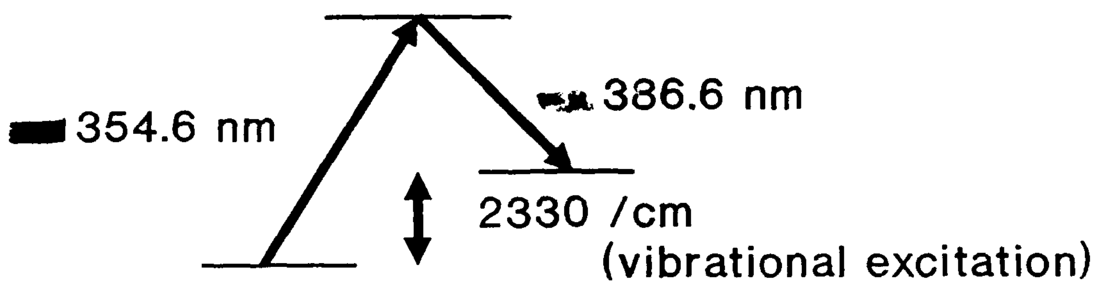
- Below 15 km, Mie scattering from non-gaseous particles contributes strongly to lidar backscatter.
- In the same region, extinction of the laser cannot be ignored if 5 - 10% measurements are needed.

Current Status:

- High altitude Rayleigh density measurements are being made to 85 km.
- The lower bound of the measurements is between 20 and 40 km.
- Rawinsondes provide normalization.

Raman Lidar:

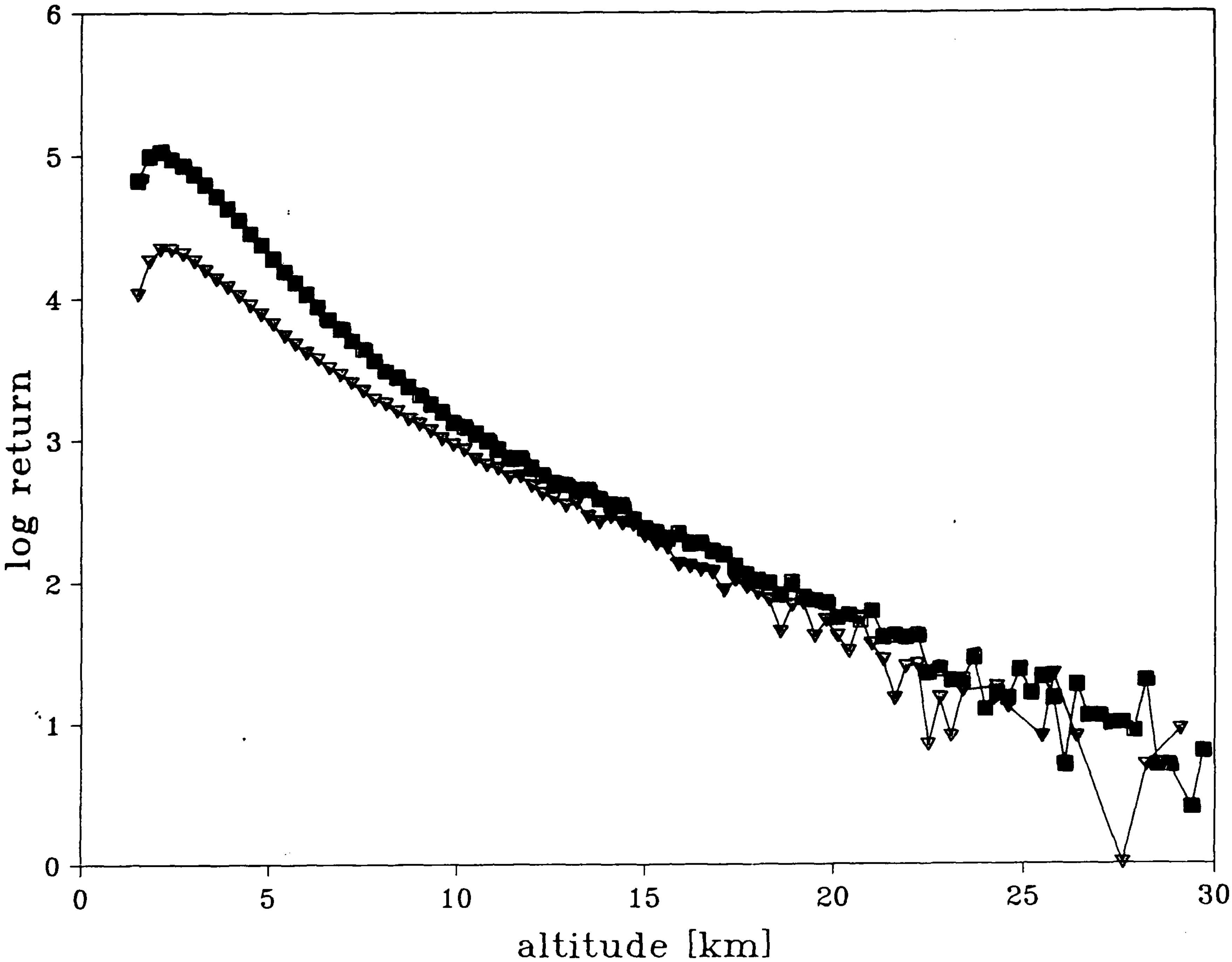
- Sensitive only to nitrogen backscatter.



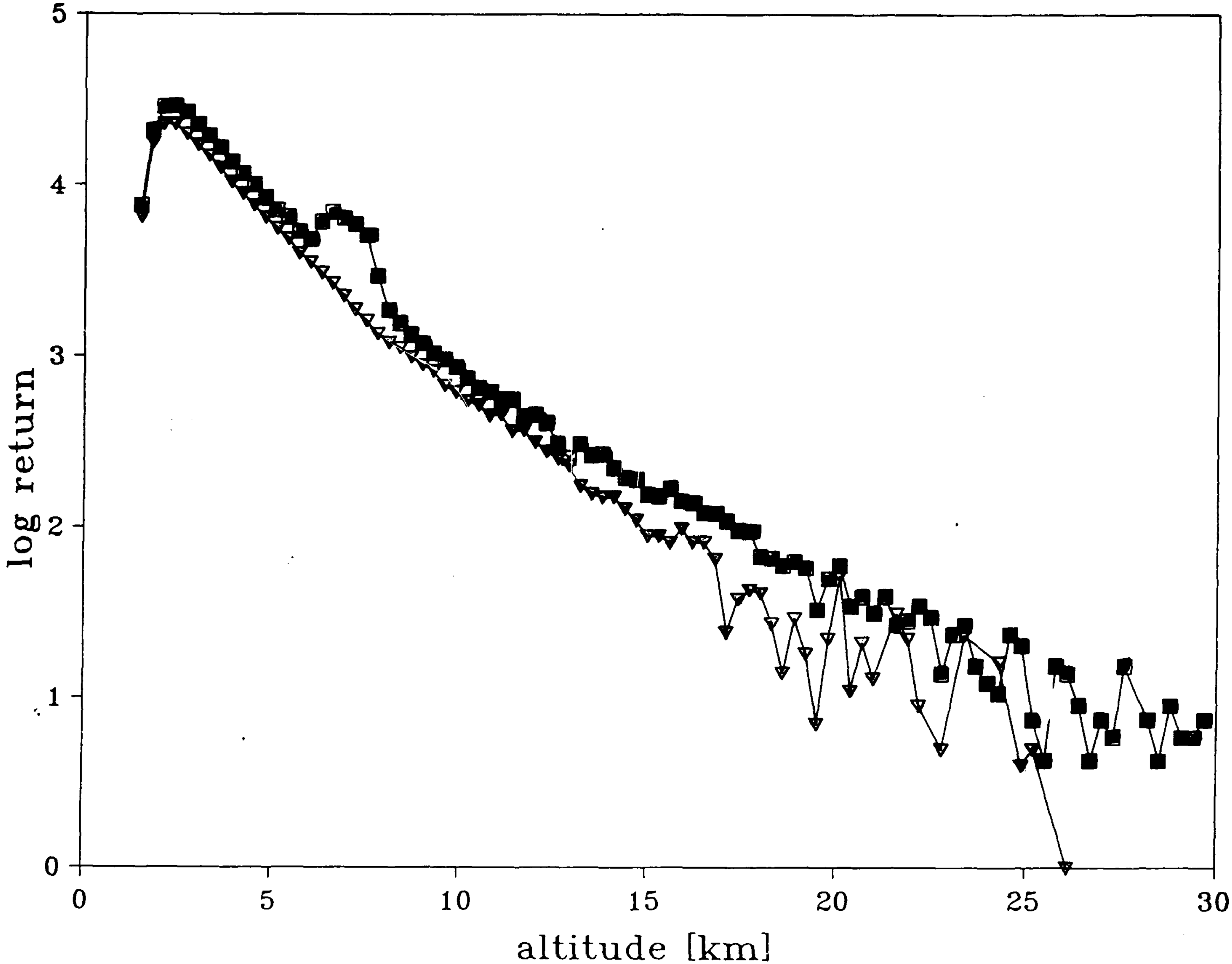
- Vibrational Raman cross section is small - 0.1% of Rayleigh cross section.
- Use simultaneous Rayleigh and Raman lidar - each in its useful regime.

Extinction is present in both Raman (inelastic) and Rayleigh + Mie (elastic) channels.

- Assume extinction is equal for both despite difference in returned wavelengths.
- Use inversion of lidar equation to derive extinction from elastic return.



log return
altitude [km]
0
1
2
3
4
5
6
0
5
10
15
20
25
30



log return
altitude [km]
0
1
2
3
4
5
0
5
10
15
20
25
30

The two-way atmospheric transmission is given by:

$$T(z) = 1 - \frac{2\kappa(z_0)}{z_0^2 S(z_0)} \int_{z_0}^{z} z^2 S(z) dz$$

where $S(z)$ is the lidar signal, and $\kappa(z)$ is the extinction.

Alternatively, if $T(z_f)$ is known:

$$T(z) = 1 - \frac{[1 - T(z_f)] \int_{z_0}^{z} z^2 S(z) dz}{\int_{z_0}^{z_f} z^2 S(z) dz}$$

- Calibration required.
- Proper correction for overlap of laser and receiver field-of-view.
- Wide dynamic range.

Conclusion:

Self-normalized lidar density measurements are possible using a combination of Raman and Rayleigh techniques.